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# UTILITY PATENT APPLICATION TRANSMITTAL

 Attorney Docket No. **1-99**

First Inventor or Application Identifier

**MATSUI**

Title

**METHOD AND APPARATUS FOR  
MECHANOCHEMICAL POLISHING**

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

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## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

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1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
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2. ☒ Specification [Total Pages **36** ]
- Descriptive title of the Invention
- Cross Reference to Related Applications
- Background of the Invention
- Summary of the Invention
- Brief Description of the Drawings
- Detailed Description of the Preferred Embodiment
- Claims
- Abstract of the Disclosure

5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission  
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7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement  
 (when there is an assignee) ☒ Power of Attorney
9. ☐ English Translation Document (if applicable)
10. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☒ Copies of IDS Citations
11. ☐ Preliminary Amendment
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3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets **11** ]

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**37,701**

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**Applicant:** MATSUI

**For:** METHOD AND APPARATUS FOR MECHANOCHEMICAL POLISHING

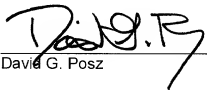
**Docket:** 1-99

**Attorney:** David G. Posz

**Date of Deposit:** November 13, 2000

I hereby certify that this certificate and the following documents are being hand-delivered to, and deposited on the above-indicated date with, Office of Initial Patent Examination at the United States Patent Office, and are addressed to the Commissioner of Patents and Trademarks/Assistant Commissioner for Patents, Washington, D.C., 20231:

- return receipt postcard;
- check for \$1164 for filing fee and assignment recordation;
- transmittal form (2 copies);
- fee calculation form (2 copies);
- 36 page specification including 43 numbered claims;
- 11 sheets of formal drawings;
- executed declaration and power of attorney;
- assignment and recordation cover sheet;
- certified copy of one priority document (JP 11-325473, JP 2000-259116); and
- IDS with PTO-1449 form and copy of 8 listed references.

  
David G. Posz

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# FEE TRANSMITTAL for FY 2000

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TOTAL AMOUNT OF PAYMENT (\$)**1164**

**Complete if Known**

Application Number \_\_\_\_\_  
 Filing Date **November 13, 2000**  
 First Named Inventor **MATSUI**  
 Examiner Name \_\_\_\_\_  
 Group/Art Unit \_\_\_\_\_  
 Attorney Docket No. **1-99**

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## FEE CALCULATION

### 1. BASIC FILING FEE

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101 710	201 355	Utility filing fee	<b>710</b>
106 320	206 160	Design filing fee	
107 490	207 245	Plant filing fee	
108 710	208 355	Reissue filing fee	
114 150	214 75	Provisional filing fee	
SUBTOTAL (1)			<b>(\$ 710)</b>

### 2. EXTRA CLAIM FEES

Total Claims	Extra Claims	Fee from Below	Fee Paid
<b>43</b>	<b>23</b>	<b>18</b>	<b>414</b>
Independent Claims	<b>0</b>	<b>80</b>	
Multiple Dependent			

\*or number previously paid, if greater. For Reissues, see below

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description
103 18	203 9	Claims in excess of 20
102 80	202 40	Independent claims in excess of 3
104 270	204 135	Multiple dependent claim, if not paid
109 80	209 40	**Rescued independent claims over original patent
110 18	210 9	**Rescued claims in excess of 20 and over original patent

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105 130	205 65	Surcharge - late filing fee or oath	
127 50	227 25	Surcharge - late provisional filing fee or cover sheet	
139 130	239 130	Non-English specification	
147 2,520	247 2,520	For filing a request for reexamination	
112 920*	212 920*	Requesting publication of SIR prior to Examiner action	
113 1,840*	213 1,840*	Requesting publication of SIR after Examiner action	
115 110	215 55	Extension for reply within first month	
116 390	216 195	Extension for reply within second month	
117 890	217 445	Extension for reply within third month	
118 1,390	218 695	Extension for reply within fourth month	
128 1,890	228 945	Extension for reply within fifth month	
119 310	219 155	Notice of Appeal	
120 310	220 155	Filing a brief in support of an appeal	
121 270	221 135	Request for oral hearing	
138 1,510	238 1,510	Petition to institute a public use proceeding	
140 110	240 55	Petition to revive - unavoidable	
141 1,240	241 620	Petition to revive - unintentional	
142 1,240	242 620	Utility issue fee (or reissue)	
143 440	243 220	Design issue fee	
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122 130	222 130	Petitions to the Commissioner	
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126 240	226 240	Submission of information Disclosure Stmt	
581 40	581 40	Recording each patent assignment per property (times number of properties)	<b>40</b>
146 710	246 355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149 710	249 355	For each additional invention to be examined (37 CFR § 1.129(b))	
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SUBTOTAL (3)			<b>(\$ 40)</b>

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## SUBMITTED BY

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Signature *David G. Posz*

Registration No. (Attorney/Agent) **37,701**

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## METHOD AND APPARATUS FOR MECHANOCHEMICAL POLISHING

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit  
5 of Japanese Patent Applications No. 11-325473 filed on  
November 16, 1999, and No. 2000-259116 filed on August 29,  
2000, the contents of which are incorporated herein by  
reference.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to mechanochemical  
polishing and more particularly, to a polishing technique  
utilizing chromium (III) oxide ( $\text{Cr}_2\text{O}_3$ ) as abrasive grains.

#### 2. Description of the Related Art

A power semiconductor device formed from a silicon  
carbide (SiC) having solid state properties with higher  
values compared to those of silicon (Si) has better  
performance than a power semiconductor device made of Si.

Specifically, a SiC power semiconductor device can function  
as a semiconductor at high temperature because of its wide  
energy gap (which is about three times larger than that of  
Si), can withstand high voltage because of its high  
dielectric breakdown withstand voltage (which is ten times  
larger than that of Si), and can accommodate higher current  
because of excellent radiating properties attributable to  
its high coefficient of thermal conductivity (which is about

three times larger than that of Si).

More specifically, for example, as shown in Fig. 22 a SiC wafer used to form an element is provided by epitaxially growing a SiC layer 101 having a low impurity concentration on a single crystal SiC substrate 100 having a high impurity concentration. An element 103 of a type that causes a current to flow in the longitudinal direction thereof (e.g., VDMOS) is formed on the SiC layer 101. While studies are being made into GaN as a material capable of emitting light having a short wavelength in the field of optical devices, SiC wafers are attracting attention as underlying substrates on which a GaN thin film is to be formed because SiC has less lattice mismatches with GaN compared to sapphire.

An SiC wafer is obtained by growing bulk single crystal SiC by sublimating SiC powder and re-crystallizing it on a seed crystal, cutting the bulk single crystal SiC into a configuration of a wafer and performing mirror finishing on a surface (cut surface) of the wafer. While a SiC layer or a GaN layer is epitaxially grown on the surface, the surface must be free of defects and must be smooth on the level of atoms in order to obtain the epitaxial layer with high crystallinity.

A common method for mirror finishing of a SiC wafer is to achieve smoothness by polishing the surface using diamond abrasive grains. This is a method for mechanical surface finishing in which the surface of SiC (material to be polished) is polished using abrasive grains made of a

material (diamond) harder than the surface. Although a smaller abrasive grain size results in a smoother surface (improved surface roughness), it cannot prevent the occurrence of defects (process-affected layer) originating from processing. Therefore, in this case, polishing is followed by a process for removing any process-affected layer as a post process such as dry etching or wet etching using hydrofluoric acid that is performed after growing an oxide film through thermal oxidation.

Further, diamond abrasive grains are expensive and become more expensive as the grain size is increased. Furthermore, when large abrasive grains are mixed in microscopic abrasive grains, surface roughness is not improved, and scratches may be produced to cause local deep defects. This results in a need for using high quality diamond abrasive grains with a uniform grain size, which also leads to an increase in the cost of abrasive grains. Process control (control of the abrasive grain size) is also difficult.

In a case of polishing using abrasive grains made of a material whose hardness is lower than a material to be polished, the processing can be performed with less damage on a processed surface. In this case, however, it is not possible to perform mechanical polishing in which the abrasive grains directly polish the material to be polished. It is preferable to adapt a polishing method in which a mechanically fragile reaction product (an oxide, compound or

the like) is formed on the surface of the material to be polished and is peed off with soft abrasive grains, i.e., so-called mechanochemical polishing (chemical mechanical polishing; MCP). It is however difficult to form a reaction product on SiC because SiC is a chemically stable material.

With respect to mechanochemical polishing methods for SiC, there is a report on a method for polishing SiC using chromium oxide as abrasive grains (M. Kikuchi, Y. Takahashi, T. Suga, S. Suzuki, and Y. Bando, "Mechanochemical Polishing of Silicon Carbide Single Crystal with Chromium (III) Oxide Abrasive", J. Am. Ceram. Soc., 75[1] (1992) 189). According to the report, polishing (MCP) can be achieved without residual distortion and scratches by performing dry polishing of SiC on a disk (fixed abrasive grains) that is obtained by fixing chromium oxide abrasive grains with resin.

Further, Japanese Patent Laid-Open No. 7-80770 proposes a method in which surface flatness of SiC is improved by using chromium oxide power that is free abrasive grains, and a polishing platen made of a material having micro-Vicker's hardness in the range from 1000 to 2000. Those methods are polishing methods that rely upon a mechanochemical phenomenon at contact points between a material to be polished and abrasive grains, and remove a reaction layer produced as a result of a direct solid phase reaction between them by a frictional action of the abrasive grains.

Such method utilizing a solid phase reaction was proposed in Japanese Patent Publication No. 56-23746, and the above-mentioned "Mechanochemical Polishing of Silicon Carbide Single Crystal with Chromium (III) Oxide Abrasive" and Japanese Patent Laid-Open No. 7-80770 are based on a combination of SiC as a material to be polished and a chromium oxide as abrasive grains.

However, in order to cause the solid phase reaction, it is assumed that it is important to put the material to be polished and abrasive grains in contact with each other with a very high pressure at the contact points between them. Referring to the processing pressure, experiments were conducted under pressures of 0.34 MPa (3.5 kgf/cm<sup>2</sup>) in the above-mentioned "Mechanochemical Polishing of Silicon Carbide Single Crystal with Chromium (III) Oxide Abrasive", and under pressure of 900 kgf/cm<sup>2</sup> in Japanese Patent Laid-Open No. 7-80770. When a high processing pressure is required and a wafer with a large diameter is polished, a polishing platen will be subjected to a very high pressure during polishing of the wafer. When several wafers are polished on the same polishing platen, a still higher pressure will be applied to the platen. Therefore, a polishing apparatus is required to have higher rigidity that is not experienced in the prior art.

Further, the processing pressure acts not only on a surface of a SiC wafer as contact points with abrasive grains but also on the wafer as a whole, which results in



problems such as the occurrence of crystal distortion and defects, and the progress of existing defects. Furthermore, if uneven force is applied, the wafer might be cracked. On the other hand, when the processing pressures is low, no  
5 solid phase reaction occurs and the polishing time is prolonged by a low reaction speed or a low polishing speed even when a reaction occurs.

#### SUMMARY OF THE INVENTION

10 The present invention has been made under such limitations, and an object of the present invention is to provide a method and an apparatus for mechanochemical polishing, which make it possible to efficiently polish a hard material such as SiC at a low processing pressure.

15 According to the present invention, briefly, when a surface of a semiconductor wafer is polished using abrasive grains made of chromium (III) oxide, an oxidizing agent is supplied to exist on the surface of the semiconductor wafer to be polished. The abrasive grains made of chromium (III)  
20 oxide naturally serve as a catalyst for forming an oxide on the surface of the semiconductor wafer (for example, SiC), and the oxidizing agent further increases an amount of oxygen that reacts with the semiconductor wafer. As a result, polishing efficiency is improved. A hard material such as  
25 SiC can be polished efficiently even at a low processing pressure.

## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will become more readily apparent from a better understanding of the preferred embodiments described below  
5 with reference to the following drawings, in which;

FIG. 1 is a schematic view showing a mechanochemical polishing apparatus in a first preferred embodiment of the invention;

FIG. 2 is a chart showing a change in surface  
10 roughness relative to time;

FIG. 3 is a chart showing a change in surface roughness relative to time;

FIG. 4 is a chart showing a change in surface roughness relative to time;

15 FIG. 5 is a chart showing a change in surface roughness relative to time;

FIG. 6 is a chart showing a change in surface roughness relative to time;

20 FIG. 7 is a chart showing a change in surface roughness relative to time;

FIG. 8 is a graph showing surface roughness relative to polishing time;

FIG. 9 is a graph showing surface roughness relative to polishing time;

25 FIGS. 10 to 13 are schematic views showing mechanochemical polishing apparatuses as modifications in the first embodiment;

FIGS. 14 and 15 are schematic views showing mechanochemical polishing apparatuses in a second preferred embodiment of the invention;

FIGS. 16 to 21 are schematic views showing  
5 mechanochemical polishing apparatuses in a third preferred embodiment of the invention; and

FIG. 22 is a cross-sectional view showing a semiconductor device as a related art.

#### 10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

##### (First Embodiment)

A first preferred embodiment of the invention will now be described with reference to the drawings.

Fig. 1 is a schematic configuration diagram of a  
15 mechanochemical polishing apparatus according to the first embodiment. A polishing cloth 2 is applied to a polishing platen 1. Foamed polyurethane, unwoven fabric, felt, suede or the like is used as the polishing cloth 2. A wafer holding table 3 is provided above the polishing platen 1,  
20 and a SiC wafer 4 can be held on the wafer holding table 3. During processing, the wafer holding table 3 is pressed against the polishing cloth 2 to press a surface of the SiC wafer 4 to be polished against the same with a predetermined processing pressure. The wafer holding table 3 and polishing  
25 platen 1 can be rotated.

Further, an injector (nozzle) 5 is provided above the polishing platen 1, and chemical liquid 6 is dropped on the

polishing cloth 2 from the injector 5. The chemical liquid 6 is obtained by dispersing abrasive grains made of chromium (III) oxide in hydrogen peroxide water (oxidizing chemical liquid). That is, a mixture of chromium oxide abrasive grains and oxidizing chemical liquid is used as the chemical liquid slurry 6.

Thus, when the single crystal SiC wafer (semiconductor wafer) 4 is polished by pressing it against the polishing cloth 2 and by using powder of chromium (III) oxide as abrasive grains, hydrogen peroxide water that oxidizing chemical liquid is dropped on the polishing cloth 2 from the injector 5 and accordingly is supplied to the polished surface. Incidentally, the accuracy of processing on the wafer surface and the life of the polishing cloth can be improved by swinging the wafer holding table 3 relative to the polishing platen 1.

A method for mechanochemical polishing will now be described. First, the SiC wafer 4 is held on the wafer holding table 3. Then, the surface to be polished is pressed with a predetermined processing pressure against the polishing cloth 2 applied to the polishing platen 1. Further, the wafer holding table 3 and the polishing platen 1 are rotated to perform polishing with the chemical liquid 6 dropped on the polishing cloth 2.

Hydrogen peroxide water (oxidizing agent) is thus present on the polished surface during polishing, and the hydrogen peroxide water improves polishing efficiency. The

improvement of polishing efficiency is considered to be attributable to the fact that the chromium (III) oxide abrasive grains act as a catalyst for forming an oxide on the SiC surface, and the hydrogen peroxide water supplied to the polished surface increases the amount of oxygen reacting with SiC to improve reacting efficiency. It is thus possible to efficiently polish a hard material such as SiC with a low processing pressure.

The minimum pressure to allow polishing is determined by the type of the polishing cloth 2, the concentration and size of the chromium (III) oxide abrasive grains, the concentration and amount of the dropped hydrogen peroxide water, the rotational speeds of the wafer holding table 3 and polishing platen 1, etc.

According to an experiment, surface roughness (average roughness Ra along the center line) of 1.20 nm of a sample could be smoothed to 0.43 nm as a result of polishing for 30 minutes even with a low processing pressure (0.34 kgf/cm<sup>2</sup>). Referring to the polishing conditions at that time, the polishing cloth was made of foamed polyurethane; the polishing liquid was obtained by dispersing chromium (III) oxide abrasive grains of 0.5  $\mu$ m in a grain size (at a concentration of 10 % by weight) in hydrogen peroxide water (concentration of 10 %); the dropped amount of the polishing liquid was 5.0 milliliter/min.; and the rotational speed of the wafer holding table and polishing platen was 40 rpm.

Detailed results of the experiment will now be described with reference to Figs. 2 through 9.

The experiment was carried out as follows. Single crystal SiC (6H-SiC) was used as a sample, and a (0001) Si-  
5 face of the SiC wafer was polished. Referring to the polishing conditions, three types of polishing, i.e., polishing (i) with hydrogen peroxide water (oxidizing agent) dropped as described in the present embodiment, dry polishing (ii) and wet polishing (iii) were conducted for  
10 comparison. Specifically, in the polishing (i) with hydrogen peroxide water dropped per, the polishing was performed by dropping the liquid obtained by dispersing chromium (III) oxide abrasive grains (at a concentration of 10 % by weight) in hydrogen peroxide water (concentration of 10 %) on a  
15 polishing cloth. In the dry polishing (ii), the polishing was performed using a polishing cloth having chromium (III) oxide abrasive grains applied thereon. In the wet polishing (iii), the polishing was performed by dropping chromium (III) oxide liquid obtained by dispersing chromium oxide  
20 abrasive grains of 10 % by weight in water on a polishing cloth.

The evaluation of polishing was made based on changes in surface roughness as time elapsed. Specifically, change in the surface roughness of each sample was examined.

25 Foamed polyurethane was used for the polishing cloths, and abrasive grains made of chromium (III) oxide with a grain size of  $0.5\ \mu\text{m}$  were used. The processing pressure was

3.0 kgf/cm<sup>2</sup>. The surfaces to be polished were surfaces, which were processed by grinding (#8000) and had irregularities (grinding marks) in a predetermined direction cut by a grind wheel made of diamond.

Fig. 2 shows a state of a surface after the dry polishing as described above was performed for 10 minutes. The surface roughness Ra at that time was 1.11 nm. Similarly, Fig. 3 shows a state of a surface after the dry polishing was performed for 20 minutes. The surface roughness Ra at that time was 0.80 nm. Fig. 4 shows a state of a surface after the wet polishing as described above was performed for 10 minutes. The surface roughness Ra at that time was 1.15 nm. Similarly, Fig. 5 shows a state of a surface after the wet polishing was performed for 20 minutes. The surface roughness Ra at that time was 0.92 nm.

Further, Fig. 6 shows a state of a surface after the polishing was performed while dropping hydrogen peroxide water (oxidizing agent) as described above for 10 minutes. The surface roughness Ra at that time was 0.73 nm. Similarly, Fig. 7 shows a state of a surface after the polishing was performed while dropping hydrogen peroxide water (oxidizing agent) for 20 minutes. The surface roughness Ra at that time was 0.57 nm.

Fig. 8 shows a collection of data thus obtained. Polishing time is plotted along the horizontal axis of Fig. 8, and surface roughness Ra is plotted along the vertical axis. The figure showing changes in surface roughness

indicates that surface roughness was improved in a short time under the condition that (in the sample in which) the oxidizing agent was mixed. When processing was performed for 20 minutes, grinding marks had disappeared only in the case in which the oxidizing agent was mixed. It was thus confirmed that the addition of the oxidizing agent advantageously improves polishing.

Further, a similar experiment was conducted with a reduced processing pressure (polishing was performed under the same conditions as described above except the processing pressure). Specifically, wet polishing (in which chromium oxide abrasive grains of 10 % by weight were dispersed in water) and polishing with the oxidizing agent (in which chromium oxide abrasive grains of 10 % by weight were dispersed in hydrogen peroxide water (10 %)) were performed with the pressure reduced from 3.0 kgf/cm<sup>2</sup> to 0.6 kgf/cm<sup>2</sup>. Fig. 9 shows results of the experiment (changes in surface roughness).

A comparison between Fig. 9 and Fig. 8 described above indicates that, when the processing pressure is reduced, the wet polishing (wet polish) and the polishing with the oxidizing agent (oxidizing agent mixing polish) significantly differ from each other in polishing efficiency depending on whether hydrogen peroxide is present or not. For example, comparing those modes of polishing for 40 minutes, in the case of wet polishing, the experiment under the processing pressure of 3.0 kgf/cm<sup>2</sup> (Fig. 8) and the



experiment under the processing pressure of 0.6 kgf/cm<sup>2</sup> (Fig. 9) resulted in  $R_a \approx 0.6$  nm and  $R_a \approx 1.2$  nm respectively. Meanwhile, the polishing with the oxidizing agent resulted in  $R_a \approx 0.6$  nm in Fig. 8 and  $R_a \approx 0.6$  nm also in Fig. 9.

5 This indicates that the polishing efficiency of wet polishing (involving dispersion in water) significantly deteriorates when the processing pressure is decreased, and that the reduction in polishing efficiency is small for polishing in which hydrogen peroxide is mixed as an  
10 oxidizing agent.

Although no data is shown, as a result of an experiment conducted with a still lower processing pressure (0.34 kgf/cm<sup>2</sup>) under the condition that the oxidizing agent was mixed, polishing for 30 minutes reduced surface  
15 roughness  $R_a$  from 1.20 nm to 0.43 nm. It is apparent from the above facts that the mixing of hydrogen peroxide as an oxidizing agent suppresses a reduction of polishing efficiency even under a low processing pressure.

The above discussion and results of experiments  
20 indicate that a SiC wafer can be easily and efficiently polished under a low processing pressure, when the polishing is performed using chromium oxide (Cr<sub>2</sub>O<sub>3</sub>) as abrasive grains, by mixing the chromium oxide abrasive grains with an oxidizing agent. The processing pressure for polishing the  
25 wafer is more preferably in the range of 0.0098 to 0.294 MPa (in the range of 0.1 to 3.0 kgf/cm<sup>2</sup>).

When the amount of chromium oxide is kept unchanged,

polishing efficiency and hence surface roughness is improved as the size of the chromium oxide abrasive grains becomes small because the surface area of the grains increases. Therefore, a preferable abrasive grain size is  $5\mu\text{m}$  or less.

5       The following embodiments are possible as an example of an application of the present embodiment described above.

As shown in Fig. 10, similar effects can be achieved by performing polishing with a polishing cloth 2 applied with chromium oxide abrasive grains 11 on which hydrogen peroxide water (chemical liquid) 10 is dropped. Further, as shown in Fig. 11, polishing may be performed while dropping chemical liquid 6 obtained by dispersing chromium oxide abrasive grains in hydrogen peroxide water on a polishing cloth 2 to which chromium oxide abrasive grains 11 are applied. This improves polishing efficiency further because the number of abrasive grains contacting the polished surface increases.

A member made of a metal or ceramic may be used instead of a polishing cloth provided that it can hold chromium oxide abrasive grains and an oxidizing agent. Specifically, candidates for such a metal are tin, lead, aluminum, stainless steel, copper, etc.

As shown in Fig. 12, the polishing cloth may be replaced with a lapping film 30, which is obtained by uniformly applying chromium oxide abrasive grains 32 on a polyester film base 31 with a resin adhesive or a disc that is obtained by fixing chromium oxide abrasive grains with

resin. Fixed abrasive grains such as those on the lapping film 30 makes it possible to perform polishing with abrasive grains having a uniform grain size because there is no cohesion of the abrasive grains unlike free abrasive grains.

5 In consideration of the lapping film 30 that is liable to be clogged, it is advantageous to remove chips resulting from polishing by spraying hydrogen peroxide water (chemical liquid) to the film 30 under a high pressure to prevent clogging. Alternatively, when polishing is performed while  
10 dropping hydrogen peroxide water (chemical liquid) 10 on the lapping film 30 from an injector (nozzle) 5, it is advantageous in preventing clogging to employ a tape polishing method in which a SiC wafer 4 is polished with a pressure applied to the lapping film 30 while moving the  
15 lapping film 30 on a table 33 together with the film base 31 in a direction indicated by an arrow in Fig. 12.

Further, as shown in Fig. 13, a surface to be polished may be supplied with chemical liquid 40 that is obtained by dispersing solid powder having a function of catalyzing a  
20 chemical reaction of oxygen and the SiC surface, other than a chromium oxide powder, specifically, titanium oxide ( $TiO_2$ ) in the liquid that is dropped. That is,  $TiO_2$  powder is mixed in hydrogen peroxide water, and the resultant liquid is supplied to the surface to be polished from the injector 5.  
25  $TiO_2$  powder may be supplied to a surface to be polished also in second and third embodiments to be described later. As the catalyst other than a chromium oxide powder, for

promoting the chemical reaction of, for example, oxygen and a SiC surface to form a reaction product on the SiC surface, titanium oxide ( $\text{TiO}_2$ ) may be replaced with powder of cadmium sulfide ( $\text{CdS}$ ), diindium trioxide ( $\text{In}_2\text{O}_3$ ), zirconia dioxide ( $\text{ZrO}_2$ ), dialuminum trioxide ( $\text{Al}_2\text{O}_3$ ) or silicon dioxide ( $\text{SiO}_2$ ).

The solid powder ( $\text{TiO}_2$  powder or the like) having a function of catalyzing a chemical reaction may be applied to the polishing cloth 2 (member that moves relatively to the SiC wafer 4) to be supplied to the polished surface of the SiC wafer 4.

When such  $\text{TiO}_2$  powder or the like is used, in order to improve the catalytic function further, light sources 42, 43 and 44 may be used as shown in Fig. 13 to irradiate the powder (the  $\text{TiO}_2$  powder or the like) having the function of catalyzing a chemical reaction with light. Specifically, polishing may be performed with the polishing cloth 2 that is irradiated with light using the light source 43 or may be performed to the polished surface of the SiC wafer 4 that is irradiated with light using the light sources 42 and 44.

In the present embodiment, the polishing cloth 2 is disposed on the surface of the member (polishing platen 1) that moves relatively to the SiC wafer 4, and polishing is performed with the SiC wafer 4 pressed against the polishing cloth 2, which allows the SiC wafer 4 to be polished without any damage such as scratches and cracks thereon. Then, a study was made with respect to more preferable configurations of a polishing cloth to reduce damages on the

SiC wafer 4.

The above-described experiments proved that the usage of a foamed polyurethane material for a polishing cloth flattens irregularities on the surface of the wafer with high efficiency. However, some polishing cloths are likely to produce microscopic scratches and crystal distortion on the surface to be polished.

Foamed polyurethane is a hard polishing cloth that includes spherical foam cavities therein. Since the foam cavities are independent from each other, abrasive grains, chemical liquid or the like on the polishing cloth does not penetrate into the polishing cloth. It is therefore difficult to eliminate chips of a polished material that have been cut off from edges of the material and dropped on the polishing cloth. The chips are therefore likely to remain on the polishing cloth. Such chips on the polishing cloth may scratch the surface to be polished to produce scratches and crystal distortion on the surface.

Under such circumstances, it was found that the usage of a polishing cloth formed with a cavity or gap that is continuous in a direction perpendicular to the surface thereof is advantageous in preventing the generation of scratches and crystal distortion because it has improved penetrability from the surface of the polishing cloth in the direction of the depth thereof and it is soft. Since this facilitates ejection of chips of a semiconductor wafer and the like, a preferable polished surface can be formed with

no scratch, crack and crystal distortion. A structure made of at least any of synthetic fibers, glass fibers, natural fibers, synthetic resin and natural resin may be used as such a polishing cloth.

5 More specifically, polishing cloths which are especially preferred are:

(i) suede type polishing cloths which are made of polyurethane and which have a perpendicularly foamed structure;

10 (ii) unwoven type polishing cloths in which complex fabric bodies are impregnated with resin which then serves as binding material between fibers or in which a resin layer itself has a continuously foamed structure; and

(iii) cloths having a double-layer structure formed by  
15 combining an unwoven type cloth, as an underlying layer, in which complex fabric bodies are impregnated with resin which then serves as binding material between fibers or in which a resin layer itself has a continuously foamed structure, with a suede type cloth which is made of polyurethane and which  
20 has a perpendicularly foamed structure.

Those cloths were checked through experiments as described below.

First, when polyurethane having independent foams was used as a polishing cloth for water polishing that was  
25 performed while dropping pure water on the polishing cloth (a method which was adapted to clean a surface instead of processing the surface), scratches and crystal distortion

were generated on the surface. When a polishing cloth formed with a cavity or gap continuous in a direction perpendicular to the surface was used, neither scratch nor crystal distortion was generated. This revealed that chips of a material to be polished are a cause of scratches and crystal distortion.

Further, an experiment was conducted in which polishing was performed while dropping a liquid obtained by dispersing chromium oxide abrasive grains (of 10 % by weight) in hydrogen peroxide water (having a concentration of 10 %) on a polyurethane polishing cloth having an independently foamed structure and on a suede type polishing cloth (Supreme RN-H manufactured by RODEL NITTA K.K.). Then, each of the surface polished using the polyurethane having independent foams and the surface polished using the suede type was etched with liquid of potassium hydroxide (KOH), and changes in those surfaces were evaluated. As a result, it was revealed that the surface became rough when the polyurethane having independent foams was used because of the presence of scratches and crystal distortion, and that the suede type did not produce scratches and crystal distortion because the surface was not roughed.

When the efficiency of a polishing process is taken into consideration, when a polishing cloth is a structure formed with independent cavities or foams on the surface and interior thereof, it is possible to flatten and smooth an irregular surface of a semiconductor wafer in a short time

because the polishing cloth is hard and is excellent in retentivity of both abrasive grains and chemical liquid on the surface thereof. It is also possible to remove any process-affected layer generated at a step preceding  
5 polishing (a grinding process, a lapping process or the like) in a short time. In this case, a structure made of synthetic resin or natural resin is preferably used as the polishing cloth. A foamed polyurethane type polishing cloth having an independently foamed structure is especially  
10 preferred.

Therefore, it is preferable to use a foamed polyurethane type polishing cloth formed with independent cavities or gaps on the surface and interior thereof when the efficiency of the polishing process is essential.  
15 Besides, it is preferable to use a suede type polishing cloth formed with a cavity or gap which is continuous in a direction perpendicular to the surface if it is essential to obtain a polished surface with high quality having no scratch and crystal distortion.

20 Alternatively, it is possible to use a polishing cloth having a double-layer structure formed by combining a cloth which is a structure formed with a cavity or gap that is continuous in a direction perpendicular to the surface thereof as an underlying layer, and a cloth which is a  
25 structure formed with independent cavities or foams on the surface and interior thereof. In this case, the structure on the surface (the cloth contacting a wafer) provides an



excellent polishing speed and flattening efficiency, and the structure of the underlying layer (the underlying cloth) improves compliance to swells and warps of the semiconductor wafer. Accordingly, the wafer can be polished with high  
5 accuracy.

An especially preferable polishing cloth is a polishing cloth having a double-layer structure including an unwoven type polishing cloth as an underlying layer in which complex fabric bodies are impregnated with resin which then  
10 serves as binding material between fibers or in which a resin layer itself has a continuously foamed structure, and a foamed polyurethane type cloth having an independently foamed structure bonded with the underlying layer.

(Second Embodiment)

15 A second embodiment of the invention will now be described with differences from the first embodiment in the focus of discussion.

Fig. 14 is a schematic configuration diagram showing a mechanochemical polishing apparatus according to the second  
20 embodiment. This apparatus uses a mixture of chromium oxide and solid powder, specifically, powder of manganese dioxide ( $MnO_2$ ), having an oxidizing function, which is applied as abrasive grains 50 to a polishing cloth 2 (a member that moves relative to a SiC wafer 4). Accordingly, the mixture  
25 including the powder as an oxidizing agent is supplied to the surface of the SiC wafer 4 to be polished.

Referring to steps for polishing, the SiC wafer 4 is

polished with chromium oxide abrasive grains and the powder of manganese dioxide applied to the polishing cloth 2 as abrasive grains 50. Since manganese dioxide has an oxidizing function, it reacts with SiC to form an oxide on the surface of SiC. Chromium oxide abrasive grains promote the oxidation as a catalyst and serve as polishing abrasive grains for removing the oxide thus formed. This improves polishing efficiency and makes it possible to perform polishing even with a low processing pressure.

The present embodiment may be modified as follows.

As shown in Fig. 15, hydrogen peroxide water (chemical liquid) 52 may be dropped on the polishing cloth 2 from an injector 5 when chromium oxide abrasive grains and powder of manganese dioxide is applied to the polishing cloth 2 as the abrasive grains 50. This makes it possible to improve oxidizing efficiency (polishing efficiency). In this case, manganese dioxide and hydrogen peroxide reacts with each other to produce oxygen, which improves efficiency further. Hydrogen peroxide water including chromium oxide abrasive grains dispersed therein may be used as the chemical liquid 52.

Referring to Fig. 15, liquid obtained by dispersing the powder of manganese dioxide in a dispersing medium (e.g., water) may be used as the chemical liquid 52. That is, the solid state powder ( $MnO_2$ ) having an oxidizing function may be supplied to the surface of the wafer 4 to be polished by dispersing it in a droplet. As the powder having an

oxidizing function, it is possible to use powder of dimanganese trioxide ( $Mn_2O_3$ ) or a mixture of powder of  $MnO_2$  and powder of  $Mn_2O_3$ , in addition to powder of manganese dioxide ( $MnO_2$ ).

5 When a lapping film (see Fig. 12) is used, a solid powder having an oxidizing function may be applied to the film on which chromium oxide abrasive grains are fixed, and otherwise, a mixture of chromium oxide abrasive grains and solid powder having an oxidizing function may be fixed on a  
10 film. The solid powder having an oxidizing function used in this case may be  $MnO_2$ ,  $Mn_2O_3$ ,  $BaCO_3$ ,  $CaCO_3$ ,  $SiO_2$ ,  $Fe_2O_3$ ,  $Fe_3O_4$ ,  $MgO$ ,  $In_2O_3$ , or the like.

(Third Embodiment)

A third embodiment of the invention will now be  
15 described with differences from the first embodiment in the focus of discussion.

In the present embodiment, gas including at least oxygen, specifically, oxygen gas is used as an oxidizing agent. As shown in Fig. 16, an apparatus having a structure  
20 like a hermetically sealed vessel is employed to keep a surface to be polished in an oxidizing gaseous atmosphere. Specifically, a polishing platen 1, a polishing cloth 2 and a wafer holding table 3 are provided in an oxygen atmosphere generating chamber 60. Oxygen atmosphere is maintained in  
25 the chamber 60, and polishing is performed in the oxygen atmosphere while supplying oxygen gas to the surface to be polished.

Referring to steps for polishing, oxygen atmosphere is generated in the chamber 60 after setting a SiC wafer 4 on the wafer holding table 3. Polishing is then performed in the oxygen atmosphere. That is, the SiC wafer 4 is polished on the polishing cloth 2 on which chromium oxide abrasive grains 11 are applied. At this time, oxygen is supplied to the contact surface between the SiC wafer 4 and the polishing cloth 2.

Instead of using the apparatus shown in Fig. 16, as shown in Fig. 17, oxygen gas may be blown from a gas injector 70 toward a part to be polished (polished surface) to be supplied to the polished surface. Specifically, oxygen gas is blown from the gas injector 70 toward the polishing cloth 2 (a part of the polishing cloth 2 located at an upstream side of the SiC wafer 4) immediately before the polishing cloth 2 is put into contact with the SiC wafer 4.

Further, instead of the apparatus shown in Fig. 16, an oxygen gas supply channel 80 is provided in the polishing platen 1 as shown in Fig. 18. Specifically, the gas channel 80 supplies oxidizing gas to the surface to be polished through a member that moves relative to the SiC wafer 4. Oxygen gas is blown from the bottom side of the polishing cloth 2 (the side of the member that moves relative to the SiC wafer 4) through the channel 80 toward the part of the surface of the polishing cloth 2 for performing polishing.

In this case, a cloth having microscopic holes to allow passage of the gas is chosen as the polishing cloth 2.

For example, the polishing cloth 2 can be made of polyurethane having independent foams. In this case, the polishing cloth 2 would have holes penetrating from the top to the bottom thereof if the foamed portion is large enough.

5 The polishing cloth 2 can also be made of unwoven fibers having continuous foams allowing oxygen to pass therethrough. The supplied gas is not limited to oxygen gas, but may be other gases such as water vapor provided that it includes at least oxygen.

10 As shown Fig. 19, when the SiC wafer 4 is polished on the lapping film 30 that is provided by uniformly applying chromium oxide particles 32 on the film base 31 with resin adhesive, it is possible to prevent clogging more reliably by blowing oxygen gas (in a broad sense, gas including  
15 oxygen) from the gas injector 70.

As shown in Fig. 20, the SiC wafer 4 may be polished while being heated to promote a reaction (to improve polishing efficiency). In Fig. 20, the SiC wafer 4 is heated by heaters 90 and 91. Otherwise, as shown in Fig. 21, the  
20 SiC wafer 4 may be polished with a part of the same protruding from an edge of the polishing cloth 2 (polishing platen 1), and heating may be performed by irradiating the protruding region 4a with infrared light from a light source  
25 swung. 95.

Thus, the heating means 90, 91 and 95 for heating at least a part of the surface to be polished may be provided.

They are also implemented in the above-described embodiments. Further, polishing efficiency may be improved by heating the polishing cloth which holds chromium oxide abrasive grains and an oxidizing agent, the lapping film to which metal, ceramic or chromium oxide particles are applied or the disc obtained by fixing chromium oxide abrasive grains with resin.

While the present invention has been shown and described with reference to the foregoing preferred embodiments, it will be apparent to those skilled in the art that changes in form and detail may be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A method for mechanochemical polishing, comprising:  
preparing abrasive grains made of chromium (III)  
oxide; and

polishing a surface of a semiconductor wafer by  
mechanochemical polishing using the abrasive grains in a  
state where an oxidizing agent exists on the surface of the  
semiconductor wafer.

2. The method according to claim 1, wherein the  
oxidizing agent is an oxidizing chemical liquid.

3. The method according to claim 2, wherein the  
oxidizing chemical liquid is hydrogen peroxide water.

4. The method according to claim 2, wherein the  
oxidizing chemical agent is dropped to be supplied to the  
surface of the semiconductor wafer.

5. The method according to claim 1, wherein the  
oxidizing agent is a solid powder having an oxidizing  
function.

6. The method according to claim 5, wherein the solid  
powder includes at least one of manganese dioxide and  
dimanganese trioxide.

7. The method according to claim 5, wherein the surface of the semiconductor wafer is polished on a member that moves relatively to the semiconductor wafer, the member holding the solid powder thereon.

8. The method according to claim 5, wherein the solid powder is dispersed in a liquid that is dropped to be supplied to the surface of the semiconductor wafer.

9. The method according to claim 1, wherein the oxidizing agent is a gas containing oxygen.

10. The method according to claim 9, wherein the gas contains one of oxygen gas and water vapor.

11. The method according to claim 9, wherein the gas is sprayed to a member for polishing the surface of the semiconductor wafer to be supplied to the surface.

12. The method according to claim 9, wherein:  
the surface of the semiconductor wafer is polished on a member that is moved relatively with respect to the semiconductor wafer; and  
the gas is supplied to the surface of the semiconductor wafer through the member.

13. The method according to claim 9, wherein the



surface of the semiconductor wafer is polished in an atmosphere including the gas so that the gas is supplied to the surface of the semiconductor wafer.

14. The method according to claim 1, wherein a solid powder made of a material other than chromium (III) oxide is supplied to the surface of the semiconductor wafer when the surface is polished, the material having a function for catalyzing a chemical reaction.

15. The method according to claim 14, wherein the solid powder is dispersed in a liquid that is dropped to be supplied to the surface of the semiconductor wafer.

16. The method according to claim 14, wherein the solid powder is disposed on a member that is moved relatively with respect to the surface of the semiconductor wafer in contact with the surface when the surface is polished.

17. The method according to claim 14, wherein the solid powder contains at least one of titanium dioxide, cadmium sulfide, and diindium trioxide.

18. The method according to claim 14, wherein the solid powder is irradiated with light when the surface of the semiconductor wafer is polished.

19. The method according to claim 1, wherein the surface of the semiconductor wafer is polished while being heated.

20. The method according to claim 1, wherein the semiconductor wafer is made of silicon carbide.

21. The method according to claim 1, wherein the surface of the semiconductor wafer is polished with a processing pressure in a range of 0.0098 to 0.294 MPa (0.1 to 3.0 Kg/cm<sup>2</sup>).

22. A mechanochemical polishing apparatus, comprising:  
a holding table for holding a semiconductor wafer thereon;

a member facing the holding table and movable relatively with respect to the semiconductor wafer held on the holding table to polish a surface of the semiconductor wafer using abrasive grains made of chromium (III) oxide; and

oxidizing agent supply means for supplying an oxidizing agent to the surface of the semiconductor.

23. The apparatus according to claim 22, wherein said oxidizing agent supply means is an injector disposed above the member for supplying the oxidizing agent to the surface.

24. The apparatus according to claim 23, wherein the oxidizing agent supplied to the surface through the injector is one of an oxidizing chemical liquid and an oxidizing gas.

25. The apparatus according to claim 22, wherein the member serves as said oxidizing agent supply means and holds a solid powder as the oxidizing agent thereon.

26. The apparatus according to claim 22, wherein said oxidizing agent supply means is a hermetically sealed vessel accommodating therein the holding table holding the semiconductor wafer and the member, and having an atmosphere including an oxidizing gas as the oxidizing agent.

27. The apparatus according to claim 22, wherein said oxidizing agent supply means is a passage provided in the member and supplies an oxidizing gas as the oxidizing agent toward the surface of the semiconductor wafer through the passage.

28. The apparatus according to claim 22, further comprising heating means for heating the surface of the semiconductor wafer when the surface is polished.

29. The apparatus according to claim 22, further comprising an injector for supplying a liquid to the surface

of the semiconductor wafer, the liquid including a solid powder made of a material other than chromium (III) oxide, for catalyzing a chemical reaction.

30. The apparatus according to claim 29, wherein the injector serves as the oxidizing supply means and supplies the oxidizing agent together with the solid powder, to the surface of the semiconductor wafer.

31. The apparatus according to claim 29, further comprising a light source for irradiating the solid powder with light.

32. The apparatus according to claim 22, wherein the member holds a solid powder made of a material other than chromium (III) oxide, for catalyzing a chemical reaction.

33. The apparatus according to claim 32, further comprising a light source for irradiating the solid powder with light.

34. The apparatus according to claim 22, wherein the member has a polishing cloth on a surface thereof for polishing the surface of the semiconductor wafer.

35. The apparatus according to claim 34, wherein the polishing cloth has a cavity that is continuous in a

direction perpendicular to the surface of the member.

36. The apparatus according to claim 34, wherein the polishing cloth is made of one selected from a group consisting of synthetic fibers, glass fibers, natural fibers, synthetic resin and natural resin.

37. The apparatus according to claim 34, wherein the polishing cloth is a suede type, made of polyurethane, and has a perpendicularly foamed structure;

38. The apparatus according to claim 34, wherein the polishing cloth includes an unwoven type polishing cloth in which complex fabric bodies are impregnated with resin serving as a binding material between fibers or in which a resin layer has a continuously foamed structure.

39. The apparatus according to claim 38, the polishing cloth includes the unwoven type polishing cloth and a suede type polishing cloth bonded to the unwoven type polishing cloth at a side of the semiconductor wafer, the suede type polishing cloth being made of polyurethane and having a perpendicularly foamed structure.

40. The apparatus according to claim 34, wherein the polishing cloth has a plurality of cavities at the surface and an inside thereof, the plurality of cavities being

independent from each other.

41. The apparatus according to claim 40, wherein the polishing cloth is made of one of synthetic resin and natural resin.

42. The apparatus according to claim 41, wherein the polishing cloth is made of formed polyurethane.

43. The apparatus according to claim 34, wherein the polishing cloth includes a first cloth disposed on the surface of the member and including a cavity that is continuous in a direction perpendicular to the surface of the member, and a second cloth bonded to the first cloth at an opposite side of the member and including a plurality of cavities independent from each other at a surface and an inside thereof.

#### ABSTRACT OF THE DISCLOSURE

In a mechanochemical polishing apparatus, a SiC wafer is held on a wafer holding table. The surface of the wafer to be polished is pressed against a polishing cloth applied to a polishing platen with a predetermined processing pressure. The wafer holding table and polishing platen are then rotated to perform polishing with chemical liquid dropped on the polishing cloth. The chemical liquid includes chromium (III) oxide as abrasive grains and hydrogen peroxide water (oxidizing agent) for improving polishing efficiency.

FIG. 1

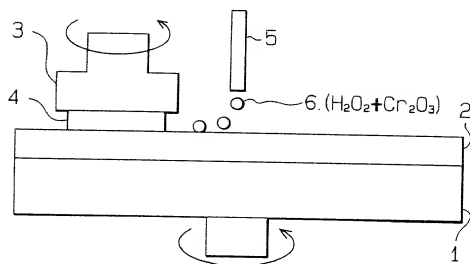


FIG. 2

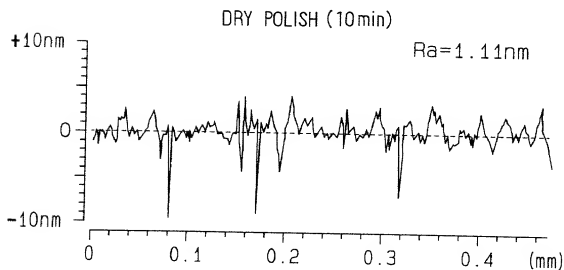




FIG. 3

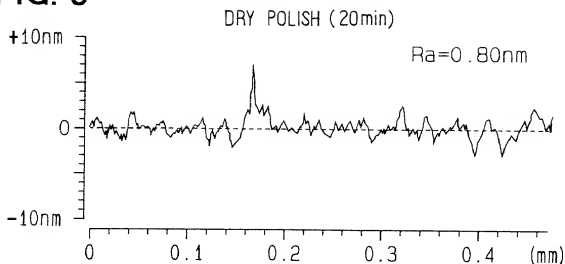


FIG. 4

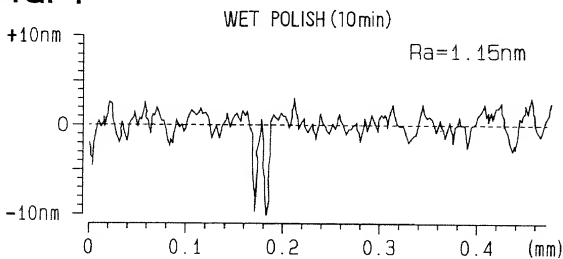


FIG. 5

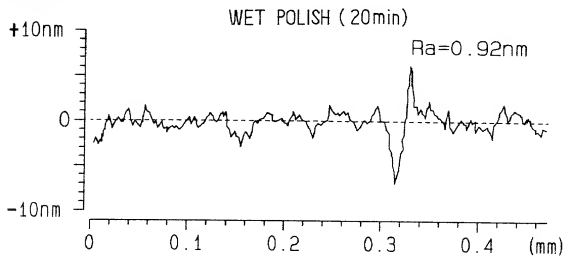


FIG. 6

OXIDIZING AGENT  
MIXING POLISH (10min)

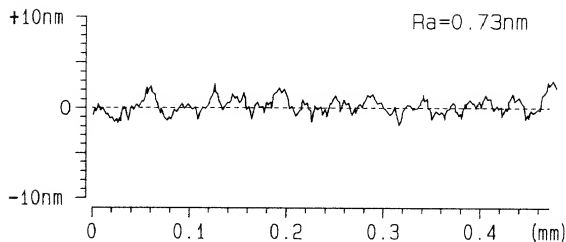


FIG. 7

OXIDIZING AGENT  
MIXING POLISH (20min)

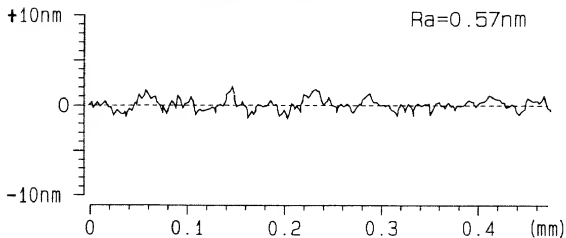






FIG. 10

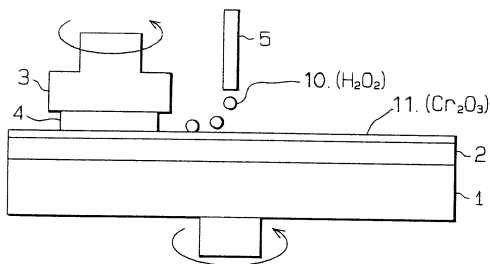


FIG. 11

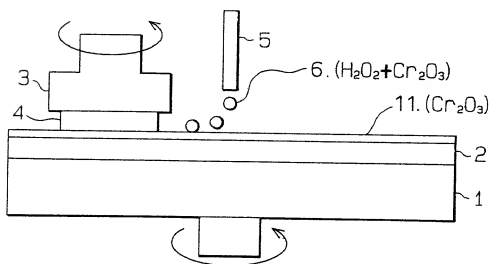


FIG. 12

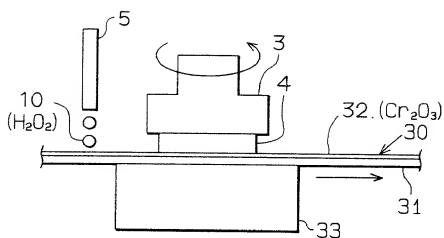


FIG. 13

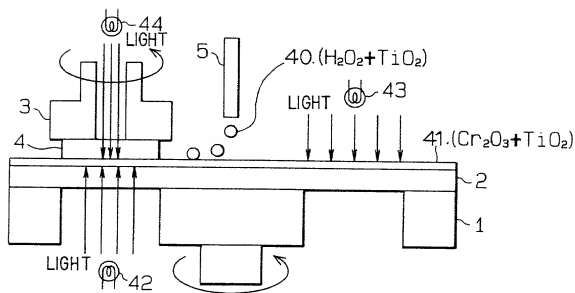


FIG. 14

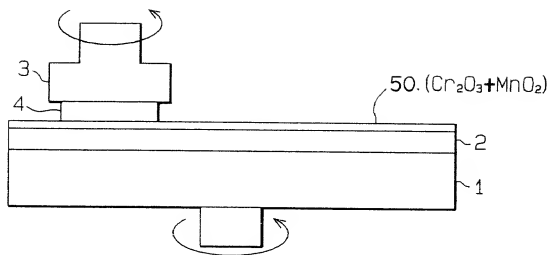


FIG. 15

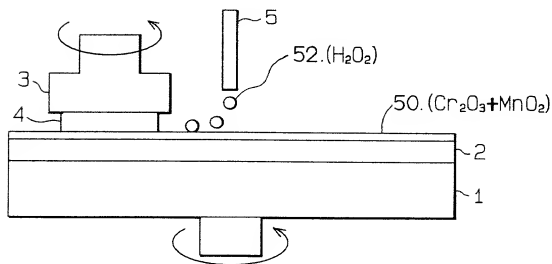


FIG. 16

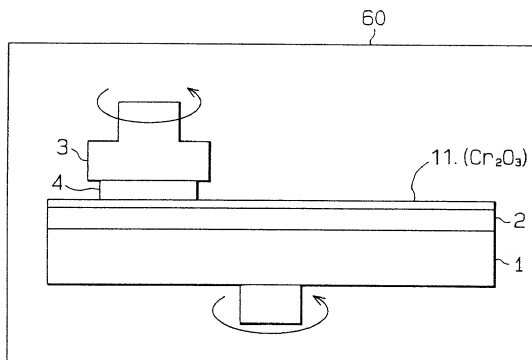


FIG. 17

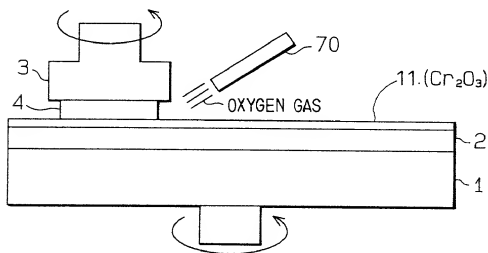




FIG. 18

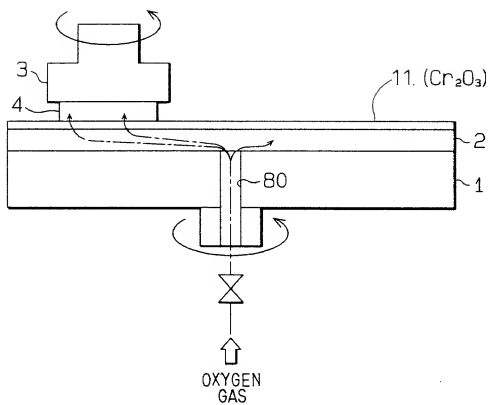


FIG. 19

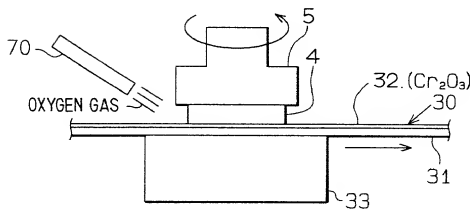


FIG. 20

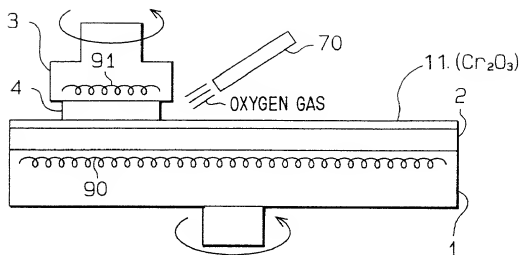


FIG. 21

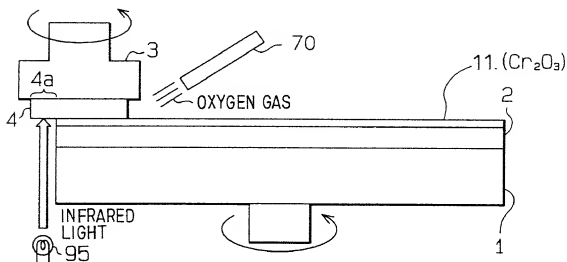
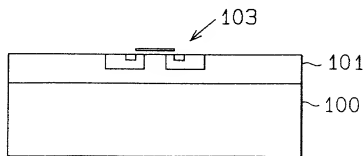


FIG. 22 RELATED ART



DGP

Declaration and Power of Attorney for Patent Application  
 特許出願宣誓書及び委任状  
 Japanese Language Declaration  
 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者(下記の氏名が一つの場合)もしくは最初かつ共同発明者であると(下記の名称が複数の場合)信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND APPARATUS FOR MECHANOCHEMICAL POLISHING

上記発明の明細書(下記の欄で×印がついていない場合は、本書に添付)は、

the specification of which is attached hereto unless the following box is checked:

☐ \_\_\_\_\_に提出され、米国出願番号または特許協力条約国際出願番号を \_\_\_\_\_とし、(該当する場合) \_\_\_\_\_に訂正されました。

☐ was filed on \_\_\_\_\_ as United States Application Number or PCT International Application Number \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されたとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

**Japanese Language Declaration**  
(日本語宣言書)

DGP

Prior Foreign Application(s)

Priority Not Claimed

外国での先行出願

(優先権主張なし)

1.	11-325437	Japan	16/NOVEMBER/1999	<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
2.	2000-259116	Japan	29/AUGUST/2000	<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
3.				<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
4.				<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
5.				<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
6.				<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	
7.				<input type="checkbox"/>
	(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	

☐ Additional Foreign Application(s) is(are) listed on the attached sheet which is incorporated herein by reference.

私は、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)
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(Application No.) (出願番号)	(Filing Date) (出願日)
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私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1.56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

Application No. (出願番号)	Filing Date (出願日)
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Status : (現況)	Patented, (特許許可済)	Pending, (係属中)	Abandoned (放棄済)
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# Japanese Language Declaration (日本語宣言書)

私は、私自身の知識に基いて本宣言書中で私が行う表明が真実であり、かつ私の入手した情報と私の信じることに基く表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基き、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行えば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

委任状： 私は下記の発明者として、本出願に関する一切の手續を米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

David G. Posz, Reg. No. 37701 of LAW OFFICE OF DAVID G. POSZ, who is a registered Patent Attorney.

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唯一または第一発明者 (Full name of sole or first inventor) Masaki MATSUI

発明者の署名 (Inventor's Signature)

*Masaki Matsui*

日付 (Date)

*November 3 2000*

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国籍 (Citizenship) Japan

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1-1, Showa-cho, Kariya-city, Aichi-pref., 448-8661 JAPAN

☐ Additional Inventor(s) is (are) listed on the attached sheet which is incorporated herein by reference.